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Evaluation of Exhaust Collection Configuration on Diesel Particulate Measurement

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16. ABSTRACT

On February 1, 1979, the EPA published proposed rules regulating particulate emissions for light-duty diesel vehicles. Questions both internal and external to EPA concerning the practicality and necessity for these requirements resulted in the initiation of a testing program. The test data was run according to the proposed Federal Register requirements for both FTP and HFET cycles. The two test vehicles were a 1975 Mercedes Benz 300D and a 1979 Oldsmobile 350 CID Diesel. Five different configurations of exhaust collection hardware were tested. The two vehicles were tested twice in each configuration. Previous testing programs had established a baseline particulate emission number for each vehicle. All of the individual FTP and HFET tests results are tabulated. The average FTP and HFET results for each configuration were calculated and compared to both the baseline data average, if available, and to the average result of this study. No baseline HFET data was available. In conclusion, there appears to be direct correlation between collection configurations and mass particulate emissions.

17. KEY WORDS AND DOCUMENT ANALYSIS

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Background

On February 1, 1979 the EPA published proposed rules regulating particulate emissions for light-duty diesel vehicles. Section 86.110-81(b)(3) describes the proposed exhaust collection configuration to be used in transferring the exhaust gas from the vehicle tailpipe to the dilution tunnel. The proposed regulation reads as follows:

> 86.110-81(b)(3)
>
> The transfer of heat from the vehicle exhaust gas shall be minimized between the point where it leaves the vehicle tailpipe(s) and the point where it enters the dilution tunnel (not more than 12 feet (365 cm) airstream. To accomplish this, a short length of stainless steel tubing from the tailpipe to the dilution tunnel is required. This tubing shall have a maximum inside diameter of 4.0 in. (10.2 cm). Short sections of flexible tubing at connection points are allowed.

Questions both internal and external to EPA concerning the practicality and necessity for these requirements resulted in the initiation of a testing program to evaluate the effect of the following parameters on diesel exhaust particulates:

1. Diameter of the exhaust collection configuration,
2. Length of the exhaust collection configuration,
3. Shape or number of bends in the exhaust collection configuration,
4. Internal smoothness of the exhaust collection configuration,
5. Temperature of the exhaust collection configuration.

Test Procedure

The test data was run according to the proposed Federal Register requirements for both FTP and HFET cycles. The two test vehicles were a 1975 Mercedes Benz 300D and a 1979 Oldsmobile 350 CID Diesel. A better description of the two vehicles is given in Table 1.

Five different configurations of exhaust collection hardware were tested. The two vehicles were tested twice in each configuration. The configurations are described as follows:

> Configuration #1: Twelve feet of convoluted, 2 1/2" diameter pipe, one 90° bend.
>
> Configuration #2: Thirteen feet of convoluted, 2 1/2" diameter pipe, three 90° bends.

Configuration #3: Twenty feet of convoluted, 2 1/2" diameter pipe, one 90° bend.

Configuration #4: Twelve feet of convoluted, 4" diameter pipe, one 90° bend.

Configuration #5: Twelve feet of smooth pipe, 2 1/2" diameter, one 90° bend, insulated.

Baseline Data

Previous testing programs had established a baseline particulate emission number for each vehicle. The baseline exhaust collection configuration was twelve feet 2 1/2" diameter smooth pipe with one 90° bend. The FTP test results used to determine the baseline are presented below:

Mercedes 300D		Oldsmobile 350	
FTP (gms/mile)	HFET	FTP (gms/mile)	HFET
.434		1.035	
.423		1.001	
.425		.961	
.409		.934	
.419		.956	
		1.006	
Average: .422 gms/mile		Average: .982 gms/mile	
Average of this study .439	.316	.859	.458

Test Results

All of the individual FTP and HFET tests results are tabulated in Table 2. The average FTP and HFET results for each configuration were calculated and compared to both the baseline data average, if available, and to the average result of this study. No baseline HFET data was available. The average results and percent deviation from the baseline and study averages is as follows:

	Mercedes 300D		Oldsmobile	
	FTP	HFET	FTP	HFET
Configuration #1				
Average	.404	.306	.854	.462
% Dev. from Baseline	(-) 4.27%		(-)13.03%	
% Dev. from Study Ave.	(-) 7.97%	(-)1.94%	(-)3.60%	(+) .87%
Configuration #2				
Average	.447	.3375	.872	.478
% Dev. from Baseline	(+) 5.92%		(-)11.20%	
% Dev. from Study Ave.	(+) 1.82%	(+)6.89%	(-) 1.57%	(+)4.37%
Configuration #3				
Average	.386	.288	.837	.423
% Dev. from Baseline	(-) 8.65%		(-)14.77%	
% Dev. from Study Ave.	(-)12.19	(-)8.79%	(-) 5.52%	(-)7.64%
Configuration #4				
Average	.452	.328	.910	.464
% Dev. from Baseline	(+) 6.99%		(-) 7.28%	
% Dev. from Study Ave.	(+) 2.85%	(+)3.88%	(+) 2.78%	(+)1.42%
Configuration #5				
Average	.4905	.3235	.949	.4755
% Dev. from Baseline	(+)16.23%		(-) 3.36%	
% Dev. from Study Ave.	(+)11.73%	(+)2.46%	(+) 7.12%	(+)3.82%

Attached are graphical representation of this tabulated data.

Rejected Data

Two tests on the Oldsmobile were considered to be invalid because the data was so removed from the norm. This data was an FTP value of 1.734 grams/mile and a HFET value of .027 grams/mile.

Temperature Data

Midway through the test program it was requested that temperature data be taken at the inlet to the dilution tunnel. Graphical presentation of the temperature data is not available for the 20 foot length of collection tubing (configuration No. 3). The relationship between temperature at the tunnel entrance is not a simple relationship as the temperature varies during the test. It is true, however, that the highest mass particulate values were noted in the highest average temperature configuration.

Conclusions

There appears to be direct correlation between collection configurations and mass particulate emissions. It should be noted that the same trends occur on each vehicle as displayed in the graphs. These graphs clearly show that the results are significant and repeatable.

1. Differences in collection pipe configuration have a larger effect on vehicles with lower exhaust volume flow rate. Thus the Mercedes 300D was more effected by exhaust collection configuration than the Oldsmobile. The Mercedes Benz showed a maximum of 24.88% delta and the Oldsmobile showed a maximum of 13.04%.

2. Convoluted Exhaust Pipe results in lower particulate emissions than smooth pipe.

3. A 4" diameter pipe results in higher particulate emissions than a 2½" diameter pipe.

4. A twenty foot 2½" diameter pipe results in lower particulate emissions than a twelve foot length.

5. An insulated exhaust collection system results in higher particulate emissions than uninsulated systems.

Table 1

Test Vehicle Description

	Oldsmobile	Mercedes 300D
Model Year	1978	1975
Make	Delta 88	300D
Emission Control System	None	None
Type	V-8, Diesel	I-5, Diesel
Bore x Stroke	4.06 x 3.39	3.58 x 3.64
Displacement	350 CID	3.00 litre
Rated Horsepower	120	77
Transmission	A-3	A-4
Axle Ratio	2.41	3.46
Chassis Type	Sedan	Sedan
Tire Size	FR78x15	175 SR14
Inertia Weight	4500	4000
VIN	3N69N8M153542	11511412019885

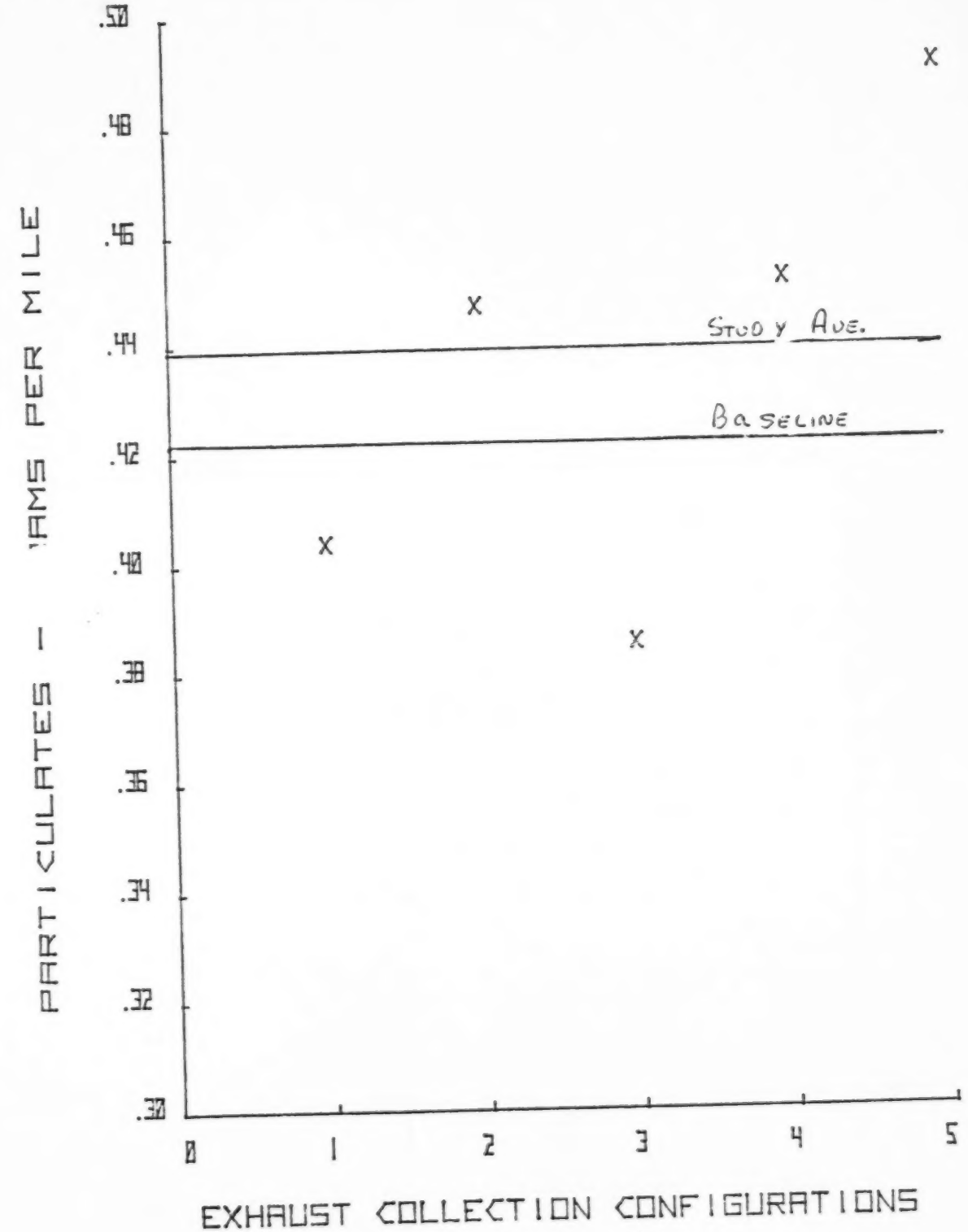
Table 2

Tabulated Test Results

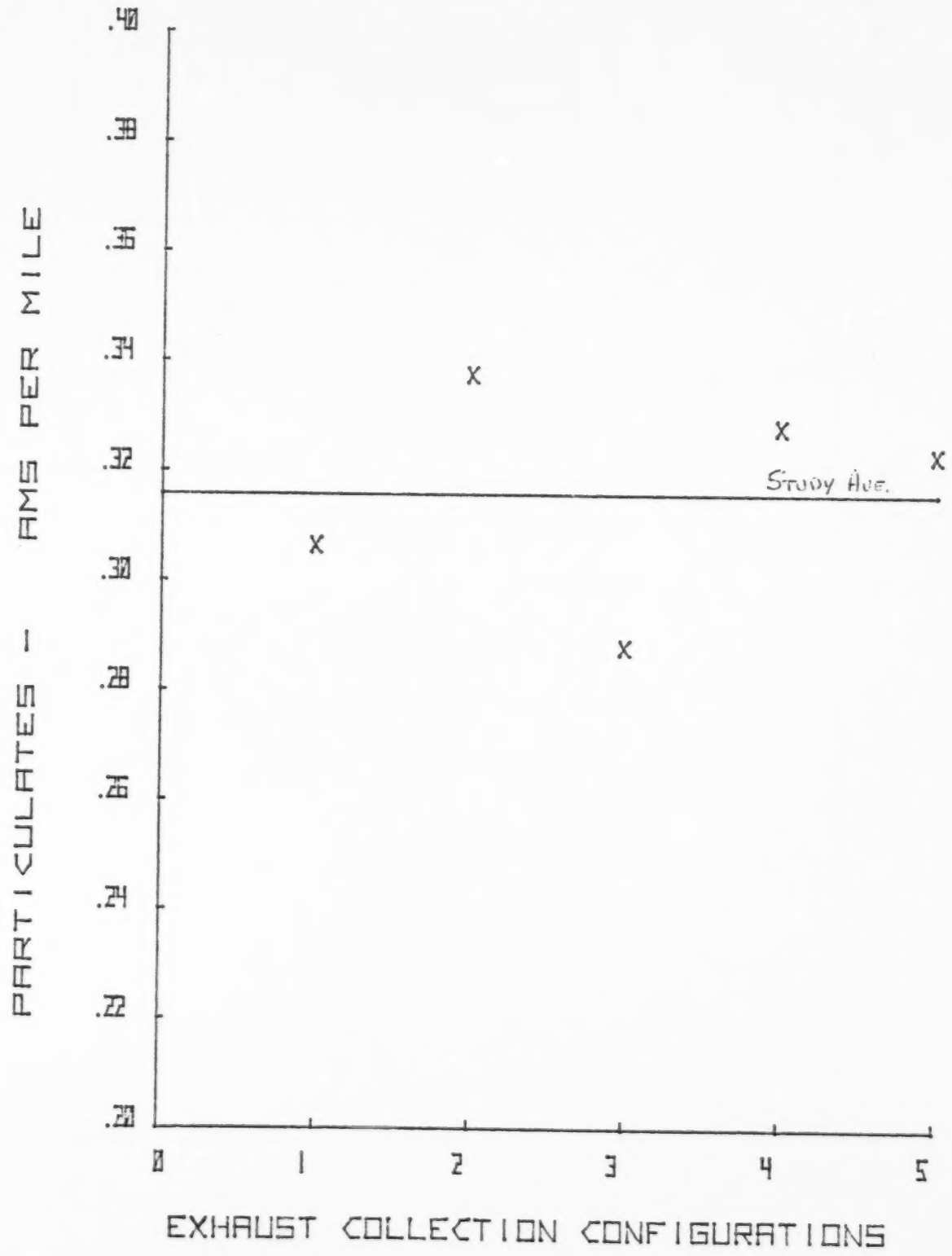
Configuration	Mercedes		Oldsmobile	
	FTP	HFET	FTP	HFET
#1	.404	.280	.812	.027*
#1	VOID	.333	.896	.462
#2	.452	.339	.872	VOID
#2	.442	.326	1.734*	.478
#3	.396	.298	.864	.433
#3	.375	.278	.810	.413
#4	.493	.332	.946	.478
#4	.410	.324	.875	.451
#5	.528	.358	.918	.476
#5	.453	.289	.980	.475

*Rejected Data

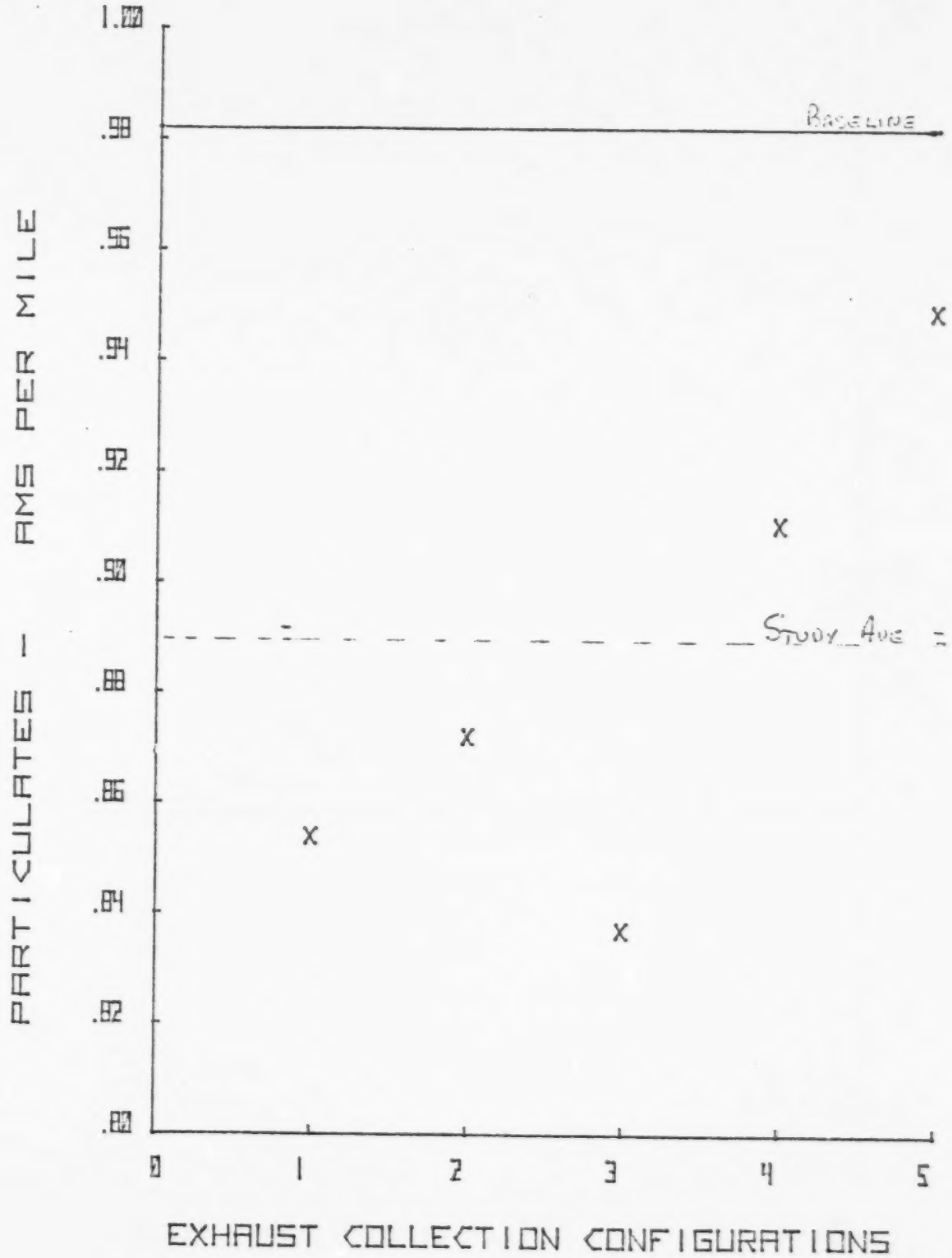
FTP - MERCEDES BENZ



HFET - MERCEDES BENZ



FTP - OLDSMOBILE



HFET - OLDSMOBILE